VERIFICATION OF TRANSLATION

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do hereby declare that I have a thorough knowledge of the Japanese and English languages and that the writing contained in the following pages is a correct translation of the attached Japanese Patent Office Certificate bearing the file reference

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I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the above-captioned application or any patent issuing therefrom.

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[DOCUMENT TITLE] SPECIFICATION
[TITLE OF INVENTION] FUEL CELL SYSTEM
[SCOPE OF CLAIM FOR PATENT]
[Claim 1]
A power generation control system for a fuel cell comprising:
target power generation amount calculating means for calculating a target power generation amount for a fuel cell;
target current calculating means for inputting the target power generation amount calculated and obtained by the target power generation amount calculating means to calculate a target current in accordance with the target power generation amount based upon a power-current characteristic obtained according to an output characteristic of the fuel cell;
operation condition monitoring means for detecting an actual voltage outputted from at least the fuel cell; and
command output calculating means for calculating a command output value commanding power of the fuel cell based upon the target current calculated and obtained by the target current calculating means and the actual voltage of the fuel cell detected by the operating condition detecting means.
[Claim 2]
A power generation control system for a fuel cell according to claim 1, further comprising:
target gas operation point calculating means for inputting the target current calculated and obtained by the target current calculating means to calculate a target operation point of a gas supplied to the fuel cell based upon a pressure characteristic of a gas of current-fuel and a gas of an oxidant in the fuel cell and a target gas operation point characteristic representing a flow characteristic of the gas of the current-fuel and the gas of the oxidant in the fuel cell;
gas controlling means for controlling a pressure and flow rate of the gas supplied to the fuel cell based upon the target gas operation point calculated and obtained by the target gas operation point calculating means; and

output characteristic learning means for learning an output characteristic of the fuel cell based upon output of the fuel cell detected by the operation condition monitoring means to correct a reference output characteristic of the fuel cell based upon the learned result, wherein:

the target current calculating means corrects the power-current characteristic based upon the output characteristic of the fuel cell obtained by the learning and the correcting by the output characteristic learning means.

[Claim 3]

A power generation control system for a fuel cell according to claim 1, further comprising:

target gas operation point calculating means for inputting the target current calculated and obtained by the target current calculating means to calculate a target operation point of a gas supplied to the fuel cell based upon a pressure characteristic of a gas of current-fuel and a gas of an oxidant in the fuel cell and a target gas operation point characteristic representing a flow characteristic of the gas of the current-fuel and the gas of the oxidant in the fuel cell;

gas controlling means for controlling a pressure and flow rate of the gas supplied to the fuel cell based upon the target gas operation point calculated and obtained by the target gas operation point calculating means; and

output characteristic learning means for learning an output characteristic of the fuel cell based upon output of the fuel cell detected by the operation condition monitoring means to correct a reference output characteristic of the fuel cell based upon the learned result, wherein:

the target gas operation calculating means corrects the target gas operation point characteristic based upon the output characteristic of the fuel cell obtained by the learning and the correcting by the output characteristic learning means.

[Claim 4]

A power generation control system for a fuel cell according to claim 2 or 3, wherein:

the operation condition monitoring means detects an actual current outputted from the fuel cell; and

the output characteristic learning means learns the output characteristic of the fuel cell based upon the actual current and the actual pressure detected by the operating condition detecting means.

[Claim 5]

A power generation control system for a fuel cell according to claim 4, wherein:

the output characteristic learning means collects the actual current and the actual pressure of the fuel cell detected by the operation condition monitoring means during the operating of the fuel cell as needed to learn the output characteristic of the fuel cell.

[Claim 6]

A power generation control system for a fuel cell according to claim 4, wherein:

the output characteristic learning means collects the reference output characteristic of the fuel cell based upon the actual current and the actual pressure

of the fuel cell detected during a given period by the operation condition monitoring means at the time of learning a current-voltage characteristic of the fuel cell to learn the output characteristic of the fuel cell.

[Claim 7]

A power generation control system for a fuel cell according to any of claims 2, 3, 4, 5, and 6, wherein:

the output characteristic learning means is provided with plural reference output characteristics of the fuel cell in accordance with temperatures of the fuel cell to collect the reference output characteristic of the fuel cell in accordance with an actual temperature based upon the learned result.

[Claim 8]

A power generation control system for a fuel cell according to any of claims 2, 3, 4, 5, 6, and 7, wherein:

the target power generation amount calculating means calculates the target power generation amount in consideration of consumption power consumed by a load of an auxiliary device based upon power generation of the fuel cell and corrects a consumption power characteristic of the load of the auxiliary device at the time of correcting the characteristic of the power-current of the target current calculating means or the target gas operation point characteristic of the target gas operation point calculating means based upon the output characteristic of the fuel cell obtained the learning of the output characteristic learning means.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[TECHNICAL FIELD OF THE INVENTION]

The present invention relates to a power generation control system for a fuel cell which appropriately controls a power generation amount even if an output characteristic of the fuel cell is lowered.

[0002]

[CONVENTIONAL ART]

Conventionally, as a technology of controlling a power generation amount of a fuel cell, there is known a technology described in a document as shown below (Patent Document 1). In the invention described in Patent Document 1, an output characteristic of a fuel cell is estimated using a basic output characteristic of the fuel cell, and an output current and an output voltage of an actual fuel cell, a requirement output to a fuel cell system is calculated based upon accelerator pedal position, a brake pedal position and a vehicle speed, and an operating point of the fuel cell is set from a fuel cell output determined by this requirement output and the estimated output characteristic. That is, in the aforementioned conventional technology, the power generation amount of the fuel cell is controlled based upon the command output value supplied from a vehicle control system.

[0003]

In a case where the fuel cell where the power is thus controlled is mounted in a vehicle, a drive force of the vehicle is controlled mainly by a rotational speed and torque of an engine. On the other hand, the output of the fuel cell is controlled by

voltage and current. Therefore, in a case of controlling the output of the fuel cell mounted in the vehicle, it is desirable to make an interface between the output supplied from the control system of the vehicle and the output of the fuel cell system.

[0004]

In such a fuel cell system, the output characteristic of the fuel cell may be lowered immediately after actuation of the system or due to aging variations thereof, thus lowering the output voltage. For taking out a commanded output from such a fuel cell, it is required to take out much output current. However, in a case of taking out much output current, the output voltage is lowered. Therefore, this event is repeated to get into a vicious cycle, thereby producing the possibility of being incapable of taking out a desired output as a result.

[0005]

For coping with such a problem, the technology described in Patent Document 1 is to in advance set an operating point (output current and output voltage) based upon the output characteristic of the fuel cell to control a converter so as to take out the set output current and output voltage, thus preventing an increase of the output current thereof.

[0006]

[Patent Document 1] Japanese Patent Laid-Open No. 2002-231295

[0007]

[PROBLEM TO BE SOLVED BY THE INVENTION]

In the above control system described in the above Patent Document 1, however, output current and the output voltage of the fuel cell is preset based on the corrected output characteristic thereof. Therefore, if the corrected output characteristic of the fuel cell is different from the actual output characteristic thereof, the system may fall into the above-mentioned vicious circle which brings harsh operating conditions to the fuel cell causing accelerated deterioration thereof, failing to obtain the required output power from the fuel cell.

[0008]

The present invention is made in the light of this problem. An object of the present invention is to provide a power generation control system for a fuel cell, which ensures sufficient output power of the fuel cell even at the time the output characteristic of the fuel cell is lowered, and prevents deterioration and damage thereof, coping with the changing output-characteristic thereof.

[0009]

[MEANS FOR SOLVING THE PROBLEM]

For achieving the above object, according to the present invention, a power generation control system for a fuel cell comprises:

target power generation amount calculating means for calculating a target power generation amount for a fuel cell;

target current calculating means for inputting the target power generation amount calculated and obtained by the target power generation amount calculating means to calculate a target current in accordance with the target power generation amount

based upon a power-current characteristic obtained according to an output characteristic of the fuel cell;

operation condition monitoring means for detecting an actual voltage outputted from at least the fuel cell; and

command output calculating means 106 for calculating a command output value commanding power of the fuel cell based upon the target current calculated and obtained by the target current calculating means and the actual voltage of the fuel cell detected by the operation condition monitoring means.

[0010]

[ADVANTAGE OF THE INVENTION]

According to the present invention, since the command output value of the fuel cell is calculated based upon the target current value calculated from the target power generation amount and the actual voltage of the fuel cell, even if the output characteristic of the fuel cell is lowered, the output is ensured certainly and the deterioration and the damage of the fuel cell can be prevented.

[0011]

[EMBODIMENTS OF THE INVENTION]

Embodiments of the present invention will be explained below with reference to the drawings, wherein like members are designated by like reference characters.

[0012]

FIG. 1 is a diagram showing a configuration of a power generation control system for a fuel cell according to the first embodiment of the present invention. A power generation control system according to the first embodiment shown in FIG. 1 comprises a target power generation amount calculating means 101, an operation condition monitoring unit 102, a target current calculating unit 104, a target gas operation point calculating unit 105, a command output calculating unit 106, and a gas control unit 107.

[0013]

The target power generation amount calculating unit 101 calculates a target power generation amount P0 to provide the system therewith. In the present control system applied to a fuel-cell vehicle, the target power generation amount calculating means 101 is provided in a vehicle control system, in which the target power generation amount is calculated based on the driver's demand and characteristics of the vehicle.

[0014]

The operation condition monitoring unit 102 monitors the operation status of the fuel cell by detecting an actual output voltage (actual voltage) thereof.

[0015]

The target current calculating unit 104 calculates a target current I1 from the target power generation amount P0 provided by the target power generation amount calculating means 101, based on a power-current characteristic (hereinafter referred to as PW-I characteristic) which can be obtained from a nominal I (current) -V (voltage) characteristic (i.e., reference I-V characteristic) of the fuel cell.

[0016]

Based on the target current TI calculated by the target current calculating unit 104, the target gas operation point calculating unit 105 calculates a target gas pressure and a target gas flow rate at the target operation point of fuel gas and oxidant gas supplied to the fuel cell. Although only the target gas pressure is illustrated in FIG. 1, in the target gas operation point calculating unit 105, the target gas flow rate is also included therein.

[0017]

The command output calculating unit 106 calculates a command output value for commanding a power generation amount of the fuel cell, based on the actual output voltage detected by the operation condition monitoring unit 102 and the target current I1 calculated by the target current calculating unit 104.

[0018]

The gas control unit 107 controls supply of the fuel gas and the oxidant gas to the fuel cell, based on the target gas operation point (the target gas pressure and the target gas flow rate) calculated by the target gas operation point calculating unit 105, and an actual gas pressure and an actual gas flow rate to be described later.

[0019]

FIG. 2 is a diagram showing a configuration of a fuel cell system that includes the power generation control system according to the first embodiment. In FIG. 2, the fuel cell system comprises a fuel cell stack 201 for generating power subject to supply of a fuel gas and an oxidant gas, a hydrogen gas feed system Sh which feeds hydrogen gas as fuel gas to the fuel cell stack 201, an air feed system Sa which feeds air as oxidant gas to the fuel cell stack 201, a humidification system Sw which humidifies hydrogen gas and air upstream of the fuel cell stack 201, a drive unit 209 which extracts the power generated by the fuel cell stack 201, and a controller 214. The humidification system Sw has a humidifier 202, and a deionized water pump 207 which supplies deionized water for humidification to the humidifier 202. The air feed system Sa comprises a compressor 203 which introduces air to the system, a throttle valve 205 which discharges air from the fuel cell stack 201 to the outside of the system, in which the compressor 203 and throttle valve 205 are operated to control air pressure Pa and air flow rate Qa in the system, an air pressure sensor 210 which detects air pressure Pa at an inlet of the fuel cell stack 201, and an air flow meter 212 which measures flow rate Qa of air flowing into the fuel cell stack 201. The hydrogen gas feed system Sh comprises a high-pressure gas tank 204a which stores hydrogen gas therein, a variable throttle regulator 204 which controls flow rate of the hydrogen gas, an ejector 208 which pumps unused hydrogen gas from the fuel cell stack 201 to the upstream thereof for recirculation, a purge valve 206 which discharges hydrogen gas to the outside of the system, a hydrogen gas pressure sensor 211 which detects hydrogen pressure Ph at the inlet of the fuel cell stack 201, a hydrogen gas flow meter 213 which measures flow rate Qh of hydrogen gas flowing into the fuel cell stack 201, and a controller 214 which takes in a signal of each sensor to drive each actuator based upon built-in control software . On an electrical wiring line from the fuel cell stack 201 to the drive unit 209, a voltmeter 215 and an ammeter 216 are provided, which respectively

measure the actual voltage AV and actual current AI of the output power of the fuel cell stack 201.

[0020]

In the air feed system Sa, the air is introduced into the system and compressed by the compressor 203, and properly humidified through the humidifier 202 to be fed to the fuel cell stack 201. In the hydrogen gas feed system Sh, the hydrogen gas is supplied from the high-pressure tank 204a to the system, at the pressure and flow rate thereof regulated by the regulator 204. The hydrogen gas meets at the ejector 208 with the recirculated hydrogen gas and is properly humidified through the humidifier 202 similarly in the air feed system Sa to be fed to the fuel cell stack 201.

[0021]

In the fuel cell stack 201, oxygen and hydrogen respectively contained in the air and hydrogen gas fed thereto electrochemically react with each other to generate electric power. Generated power (i.e., current) is supplied to the external system in the vehicle. The air unused for power generation in the fuel cell stack 201 is discharged to the atmosphere via the throttle valve 205. The hydrogen gas from the fuel cell stack 201, which is unused for the power generation, is introduced by the ejector 208 to a supply line upstream of the humidifier 202 to be reused for power generation.

[0022]

The controller 214 reads the detection values obtained from the air pressure sensor 210, the air flow meter 212, the hydrogen gas pressure sensor 211, the hydrogen gas flow meter 213, the voltmeter 215, and the ammeter 216. After reading the detection values from these sensors, the controller 214 determines the target current TI based on the target power generation amount P0, and based on the target current TI, the controller 214 determines target control values for controlling the compressor 203, the throttle valve 205 and the regulator 204. Further, the controller 214 determines an output current to be extracted from the fuel cell stack 201 to the drive unit 209 based on the actual gas pressure and gas flow rate obtained from the above-described sensors, and gives the output current as the command output power value CPW to the drive unit 209.

[0023]

The components of the fuel cell system FCS shown in FIG. 2 and the components of the power generation control system S1 shown in FIG. 1 have the following relationships. The voltmeter 215 corresponds to the operation status monitoring system 102. The controller 214 includes the target current calculating unit 104, the target gas operation point calculating unit 105, and the command output power calculating unit 106. The compressor 203, the regulator 204, and the throttle valve 205 are included in the gas control system 107.

[0024]

FIG. 3 is a graph showing nominal I-V characteristic (1) of a fuel cell in good condition with low operating hours, and I-V characteristic (2) of the fuel cell with the performance thereof degraded due to deterioration with age or insufficient warm-up. By referring to FIG. 3, in the case where the target gas operation point is determined

based on the target power generation amount P0 required from the vehicle control system VCS, and the target power generation amount P0 is set as the command output power CPW, the output power extracted from the fuel cell is controlled to be at an output current I0 which is equal to the target current TI, assuming that the performance of the fuel cell exhibits the nominal I-V characteristic.

[0025]

However, the actual I-V characteristic of the fuel cell may deviate from the nominal I-V characteristic (1) and change to the curve (2) due to deterioration with age or insufficient warm-up. The output voltage at the output current I0 drops from V 0 to V1, and therefore only an output power PW1 that is smaller than the target power generation amount P0 can be extracted from the fuel cell.

[0026]

As the command output power value CPW is set to the target power generation amount P0, the output current is controlled to increase from I1 to I 1' in order to have the product of the detected voltage AV and current AI reach the target power generation amount P0. During this period, the target values of the pressure and flow rate of the respective hydrogen gas and air (i.e., the target gas operation point) are set to the values calculated based on the target power generation amount P0 (at the current I0) which derives from the nominal I-V characteristic. However, the I-V characteristic (2) of the fuel cell has a tendency that, in a region of the heavy-load condition at a greater output current near the output current I1, the output voltage sharply drops with increasing output current.

[0027]

Therefore, if the output current increases from I1 to I1', the output voltage drops from V1 to V1' to provide an output power PW1' lower than PW1. Accordingly, the target power generation amount P0 cannot be extracted from the fuel cell. While the system further controls to increase the output current from I1' to I1", the voltage sharply drops from V1' to V1", as can be seen from the I-V characteristic (2). As a result, the output power further decreases to PW1" that is lower than PW 1', and the desired target power generation amount P0 cannot be extracted. Moreover, the extraction of such an excess current has a risk of affecting a polymer electrolyte film of the fuel cell.

[0028]

On the other hand, according to the first embodiment, when the vehicle control system VCS requires the target power generation amount P0, the target current calculating unit 104 calculates the target current I1 based on the nominal I-V characteristic of the fuel cell. Then, the command output calculating unit 106 calculates the command output power value CPW from a product (I1×AV) of the target current I1 and the actual voltage AV of the fuel cell stack 201.

[0029]

With the above configuration, when the output current equal to the target current I1 is extracted from the fuel cell, the command output power value CPW is set to the power PW1 that is equal to the product (I1×AV) of the target current I1 and the actual voltage AV. Therefore, the operation point of the fuel cell lies on the I-V

characteristic (2). This prevents the unlimited increase of the output current from I1 to I1' and from I1' to I 1" for extraction of the target power generation amount P0, thus protecting the polymer electrolyte film of the fuel cell from excess current extraction.

[0030]

As explained above, according to the first embodiment, the command output power CPW is based on the product of the target current I1 calculated from the target power generation amount P0 and the actual voltage AV of the fuel cell. Therefore, even if the I-V characteristic of the fuel cell changes due to deterioration with age or insufficient warm-up, adjustment of the command output power value CPW can follow the changing actual I-V characteristic. Accordingly, even if the actual output power does not reach the target power generation amount P0, the system does not fall in a vicious cycle, in which increase of the output current for compensating for shortage of the output power leads to the output voltage drop, further lowering the output power. Consequently, the actual output power of the fuel cell follows the command output power value CPW for power generation thereof, whereby the deterioration thereof can be prevented.

[0031]

FIG. 4 is a diagram showing a configuration of a power generation control system S2 for a fuel cell according to the second embodiment of the present invention. The power generation control system S2 includes an I-V characteristic learning unit 103 in addition to the components of the power generation control system S 1 shown in FIG. 1.

[0032]

The operation condition monitoring unit 102 detects the actual output current AI of the fuel cell in addition to the actual output voltage AV thereof for monitoring the operation status of the fuel cell.

[0033]

The I-V characteristic learning unit 103 learns the actual I-V characteristic of the fuel cell from the actual voltage AV and the actual current AI thereof detected by the operation condition monitoring unit 102, and corrects the I-V characteristic thereof. The learned and corrected I-V characteristic is given to the target current calculating unit 104.

[0034]

The target current calculating unit 104 obtains the PW-I characteristic based on the I-V characteristic given from the I-V characteristic learning unit 103, and calculates the target current I1 based on the PW-I characteristic.

[0035]

Configurations of other components are similar to those shown in FIG. 1. Corresponding relationships between the components of the power generation control system S2 for a fuel cell shown in FIG. 4 and the components of the fuel cell system FCS shown in FIG. 2 are similar to those explained in the first embodiment. In other words, the voltmeter 215 and the ammeter 216 are included in the operation status monitoring system 102. The controller 214 includes the I-V

characteristic learning unit 103, the target current calculating unit 104, the target gas operation point calculating unit 105, and the command output power calculating unit 106. The compressor 203, the regulator 204, and the throttle valve 205 are included in the gas control system 107.

[0036]

The control process performed in the power generation control system S2 of the second embodiment will be explained with reference to FIG. 5 to FIG. 9.

[0037]

FIG. 5 is a flowchart showing a process of controlling power generation extracted from the fuel cell.

[0038]

In FIG. 5, at step S501, the target power generation amount P0 is calculated. At step S502, the target current I1 is calculated from the calculated target power generation amount P0 based on the PW-I characteristic which can be obtained from the nominal I-V characteristic. At step S503, the target operation points (i.e., the target gas pressures TPR, and the target gas flow rates TQ) of the respective fuel gas and oxidant gas supplied to the fuel cell are calculated based on the target current I1. At step S504, the supply pressure and flow rate of the fuel gas and the oxidant gas to the fuel cell are controlled based on the calculated target gas operation point, the actual gas pressures APR, and the actual gas flow rates AQ thereof. At step S505, the actual voltage AV of the fuel cell stack 201 is measured. At step S 506, the target current TI and the actual voltage AV are multiplied together to obtain the command output power value CPW (=TI×AV). At step S 507, the output power of the fuel cell is controlled based on the calculated command output power value CPW. The above process is executed at every predetermined period (for example, at every 10 ms).

[0039]

FIG. 6 is a flowchart showing a learning process of the I-V characteristic of the fuel cell. The process shown in FIG. 6 is executed at every predetermined period (for example, at every 10 ms) similar to the process shown in FIG. 5.

[0040]

In FIG. 6, at step S601, it is determined whether data of the actual voltage AV and the actual current AI of the fuel cell stack 201 is readable (that is, whether the operation of the fuel cell is not in a transient state where the operational data thereof fluctuate too widely to acquire). When it is determined that the data is readable, the process proceeds to step S602. When it is determined that the data is not readable, the process proceeds to step S604. At step S 602, the actual voltage AV and the actual current AI of the fuel cell stack 201 are measured. At step S603, the values measured at step S602 are stored into the memory.

[0041]

At step S604, it is determined whether the number of data stored at step S603 exceeds a predetermined number α (for example, 5000). When the number exceeds the predetermined number α, the process proceeds to step S605. When the number does not exceed the predetermined number α, this operation routine

ends. At step S605, it is determined whether the elapsed time from a start of the data collection or the learning time exceeds a predetermined time β (for example, three hours). When it is determined that the learning time exceeds the predetermined time β, the process proceeds to step S606. On the other hand, when it is determined that the learning time does not exceed the predetermined time β, the operation routine ends. Lastly, at step S606, the collected and stored actual voltages AV and actual currents AI are respectively averaged to obtain learning data IV1. This learning data IV1 is stored into a predetermined memory variable as data IV that represents the current actual I-V characteristic, and the operation ends.

[0042]

FIG. 7 is a flowchart showing a process of calculating the target power generation amount P0 at step S501 shown in FIG. 5.

[0043]

In FIG. 7, at step S701, it is determined whether power consumption data of auxiliary equipment for power generation of the fuel cell system FCS is to be updated, wherein, when the I-V characteristic is updated, the auxiliary equipment consumption data is updated. When it is determined at step S701 that the auxiliary equipment consumption data is updated, the process proceeds to step S702. On the other hand, when it is determined at step S701 that the auxiliary equipment consumption data is not updated, the process proceeds to step S706.

[0044]

At step S702, the latest I-V characteristic is read. At step S703, a gross power Pwgross is calculated as the product of the output current and the output voltage at a point on the read latest I-V characteristic curve, and PWgross-I characteristic is created, which represent relationship between the gross power PWgross and the output current. At step S704, auxiliary equipment power consumption PWaux for various currents are first calculated from the gas pressures and gas flow rates (i.e., the operation point) of the fuel gas and oxidant gas required for generating predetermined currents, and PWgross-PWaux characteristic is created, which represent a relationship between the auxiliary equipment power consumption PWaux and the gross power PWgross. At step S705, net power PWnet is obtained by subtracting the auxiliary equipment power consumption PWaux from the gross power Pwgross (PWnet=PWgross-PWaux) at a point on the PWgross-PWaux characteristic curve, and PWneP0aux characteristic is created, which represent a relationship between the net power PWnet and the auxiliary equipment power consumption PWaux. Then, the data stored in the memory is updated according to the created PWneP0aux characteristic.

[0045]

At step S706, target net power P0net that is required from the vehicle control system VCS is read. At step S707, target auxiliary equipment power consumption P0aux is calculated from the target net power P0net based on the PWneP0aux characteristic updated at step S705. Lastly, at step S708, the target net power P0net and the target auxiliary equipment power consumption P0aux are added to obtain target gross power P0gross (=P0net+P0aux), and the routine ends.

[0046]
FIG. 8 is a flowchart showing a process of calculating the target current I1 at step S502 shown in FIG. 5.
[0047]
In FIG. 8, at step S801, the learned latest I-V characteristic is read. At step S802, gross power PWgross is calculated as the product of the output current and the output voltage at a point on the read latest I-V characteristic curve, and PWgross-I characteristic is computed, which represent a relationship between the gross power PWgross and the output current. At step S803, the target gross poer P0gross is read. At step S804, the target current I1 is calculated from the target gross power P0gross based on the PWgross-I characteristic, and the routine ends.
[0048]
FIG. 9 is a flowchart showing a process of calculating the target gas operation point at step S503 shown in FIG. 5.
[0049]
In FIG. 9, at step S901, the target current I1 obtained in the processing at step S502 shown in FIG. 5 is read. At step S 902, the target gas pressure TPR and a target air flow rate TQair are calculated from the target current I1 based on gas operation point calculation data prepared in advance, and the routine ends.
[0050]
In the first embodiment according to the present invention, the increase in the output current in a vicious cycle from I1 to I1' and from I1' to I1" can be prevented, since the product of the target current I1 and the actual voltage AV is set as the command output power value CPW. However, in such a case, only the actual power PW1 that is smaller than the requested target power generation amount P0 can be extracted from the fuel cell.
[0051]
In the second embodiment, the actual I-V characteristic changing due to the insufficient warm-up or deterioration with age is learned through measurement of the actual voltage AV and the actual current AI of the fuel cell. The PW-I characteristic is computed based on the learned I-V characteristic, and based on the PW-I characteristic, the target current I1 is obtained from the target power generation amount P0 given from the vehicle control system VCS. In other words, the I-V characteristic as the basis for obtaining the target current TI is different between the first and second embodiments, resulting in the different target currents I1 calculated from the same target power generation amount P0.
[0052]
For example, if I-V characteristic of the fuel cell is learned to be as the curve of the I-V characteristic (3) shown in FIG. 10, an output current I2' at a point thereon achieving the required target power generation amount P0, which is a intersection between the curve of the I-V characteristic (3) and a curve representing the generated power of PW2', is determined as the target current I1. This output current I2' is greater than the output current I0 of the operation point of the fuel cell according to the first embodiment. Therefore, the target gas operation point is

controlled and shifted based on the current I2' to have greater target gas pressure TPR and target gas flow rate TQ thereof than the values obtained based on the current I0. Accordingly, regarding the I-V characteristic (3), a sharp voltage drop under the heavy load condition is prevented. The command output power value CPW is then obtained as the product of the current I2' and the voltage V2' which is the actual output voltage AV, whereby the actual output power of the fuel cell becomes substantially equal to the required target power generation amount P0.

[0053]

As explained above, in the second embodiment, even when the I-V characteristic of the fuel cell changes due to deterioration with age or insufficient warm-up, the excess current extraction in the vicious cycle can be prevented, and the output power can be substantially equal to the target power generation amount. These effects are obtained in addition to those obtained from the first embodiment.

[0054]

Further, the actual current AI and the actual voltage AV are monitored during the operation of the fuel cell with data of which are continuously collected. The actual I-V characteristic of the fuel cell is thus learned and corrected based on the collected actual current AI and actual voltage AV, whereby precise system control can be achieved.

[0055]

Further, the target power generation amount P0 is calculated, taking into account the power consumed by the auxiliary equipment associated with the system power generation. The power consumption characteristic of the auxiliary equipment (i.e., the auxiliary equipment consumption data) is also corrected when the I-V characteristic and the PW-I characteristic are corrected through the learning process. Therefore, even when the power consumption of the auxiliary equipment changes due to the correction of the I-V characteristic and the PW-I characteristic, desired target power generation amount P0 can be achieved.

[0056]

FIG. 11 is a diagram showing a configuration of the power generation control system S3 for a fuel cell according to the third embodiment of the present invention. The target current calculating unit 104 in the second embodiment obtains the PW-I characteristic based on the I-V characteristic learned and corrected by the I-V characteristic learning unit 103. In the third embodiment, the target gas operation point calculating unit 105 calculates the target gas operation point based on the I-V characteristic learned and corrected by the I-V characteristic learning unit 103. The target current calculating unit 104 has a configuration similar to that in the first embodiment.

[0057]

The target gas operation point calculating unit 105 calculates the target gas operation point (i.e., the target gas pressure TPR, and the target gas flow rate TQ) based on the target current I1 obtained by the target current calculating unit 104 and the I-V characteristic learned and corrected by the I-V characteristic learning unit 103.

[0058]
Configurations of other components are similar to those shown in FIG. 1 and FIG. 2. Relationships between the components of the power generation control system S3 for a fuel cell shown in FIG. 11 and the components of the fuel cell system FCS shown in FIG. 2 are similar to those explained in the first and the second embodiments. In other words, the voltmeter 215 and the ammeter 216 are included in the operation status monitoring system 102. The controller 214 includes the I-V characteristic learning unit 103, the target current calculating unit 104, the target gas operation point calculating unit 105, and the command output power calculating unit 106. The compressor 203, the regulator 204, and the throttle valve 205 are included in the gas control system 107.
[0059]
The control process performed in the power generation control system S3 of the third embodiment will be explained with reference to FIG. 12 to FIG. 13. The process of the output power extraction from the fuel cell, the process of learning the I-V characteristic thereof, and the process of calculating the target power generation amount P0 are similar to those shown in the respective flowcharts of FIG. 5, FIG. 6, and FIG. 7. Explanations thereof are therefore omitted.
[0060]
FIG. 12 is a flowchart showing the process of calculating the target current TI at step S502 shown in FIG. 5.
[0061]
At step S1201, the target gross power P0gross is read. At step S1202, the target current I1 is calculated from the target gross power P0gross based on the P0 gross-I characteristic prepared in advance, then the routine ends.
[0062]
FIG. 13 is a flowchart showing a process of calculating the target gas operation point at step S503 shown in FIG. 5.
[0063]
In FIG. 13, at step S1301, the latest I-V characteristic learned and corrected by the I-V characteristic learning unit 103 is read. At step S1302, the reference I-V characteristic equivalent to the nominal I-V characteristic shown in FIG. 3 and FIG. 10 are read. At step S1303, an I-V characteristic deviation ratio S which represents how much the latest I-V characteristic deviates from the reference I-V characteristic is calculated.
[0064]
The characteristic deviation ratio S is calculated, for example, as follows: S(i)=IV(i)/IVleaned(i), S=κ S(i)/N, wherein i represents an integer from 1 to N, IV(i) represents data at each of N points on the reference I-V characteristic curve, and IVlearned(i) represents data at each of N points on the learned I-V characteristic curve at the same current values as those of the N points of IV(i) on the reference I-V characteristic curve. S(i)s are thus calculated for N points in the I-V characteristic. The deviation ratio S is then calculated as an average of N S(i)s.
[0065]

At step S1304, based on the calculated deviation ratio S and reference target gas pressure data mPR0, a target gas pressure mPR is corrected as the product of the target gas pressure data mPR0 and f(S) (mPR=MPR0×f(S)). The f(S) represents a predetermined monotone increasing function which returns a positive value for the given deviation ratio S. Instead of the function f(S), table data may be used, in which positive numbers are provided for each of various possible deviation ratios S.
[0066]
At step S1305, the target current I1 obtained by calculation at step S1202 shown in FIG. 12 is read. Lastly, at step S1306, the target gas pressure TPR is calculated based on the target gas pressure mPR obtained at step S1304. The target air flow rate TQair is calculated from predetermined data prepared in advance, and the routine ends.
[0067]
In the first embodiment of the present invention, the increase in the output current in a vicious cycle from I0 to I 1' and from I1' to I1" can be prevented, since the product of the target current I1 and the actual voltage AV is set as the command output power CPW. However, in such a case, only the actual power PW1 that is smaller than the requested target power generation amount P0 can be extracted from the fuel cell.
[0068]
In the third embodiment, the actual I-V characteristic which has changed due to insufficient warm-up or deterioration with age is learned and corrected based on the monitored actual voltage AV and actual current AI of the fuel cell, and the target gas operation point is calculated based on the corrected I-V characteristic. The target current I1 is obtained from the target power generation amount P0 given from the vehicle control system VCS, based on the nominal I-V characteristic in a similar manner to that in the first embodiment. Therefore, for example, the output current is controlled to be I0 as shown in FIG. 10.
[0069]
The target gas operation point is calculated based on the obtained current I0. When it is learned that the I-V characteristic of the fuel cell has deteriorated with the voltage thereof lowered, the target gas operation point is corrected to increase the gas pressure, whereby the I-V characteristic thereof changes to recover the voltage. In other words, by increasing the gas pressure, the I-V characteristic of the fuel cell comes close to the nominal the I-V characteristic (1) shown in FIG. 10, whereby the output voltage of V0 can be obtained from the fuel cell at the output current I 0. Consequently, the command output power CPW calculated as the product of the actual current AI which is equal to I0 and the actual voltage AV which is equal to V0, becomes equal to the desired target power generation amount P0.
[0070]
There is a limit to the rise in the output voltage of the fuel cell realized by increasing the gas pressure. Therefore, when a large voltage drop in the I-V characteristic of the fuel cell occurs, the configuration according to the second embodiment may preferably be employed together with the configuration of the third

embodiment.
[0071]
As explained above, in the third embodiment, even when the I-V characteristic of the fuel cell changes due to deterioration with age or insufficient warm-up, a vicious cycle of excess current extraction can be prevented, and the output power can be substantially equal to the target power generation amount. These effects are obtained in addition to those obtained from the first embodiment.
[0072]
Further, the actual current AI and the actual voltage AV are monitored during the operation of the fuel cell with data of which are continuously collected. The actual I-V characteristic of the fuel cell is thus learned and corrected based on the collected actual current AI and actual voltage AV, whereby precise and proper system control can be achieved.
[0073]
Further, the target power generation amount P0 is calculated, taking into account the power consumed by the auxiliary equipment associated with the system power generation. The power consumption characteristic of the auxiliary equipment (i.e., the auxiliary equipment consumption data) is also corrected when the I-V characteristic and the PW-I characteristic are corrected through the learning process. Therefore, even when the power consumption of the auxiliary equipment changes due to the correction of the I-V characteristic and the PW-I characteristic, desired target power generation amount P0 can be achieved.
[0074]
A power generation control system 4 according to the fourth embodiment of the present invention will be explained next.
[0075]
In the fourth embodiment, the I-V characteristic learning unit 103 according to the second and the third embodiments learns and corrects the I-V characteristic using a small amount of data collected during a relatively short period of time such as a warm-up period. Other configurations are similar to those in the second or the third embodiment.
[0076]
A learning process of the I-V characteristic learning unit 103 will be explained with reference to a flowchart shown in FIG. 14. The learning process is executed at every predetermined time, for example, at every 10 ms, similarly to the process shown in the flowchart in FIG. 5.
[0077]
At step S1401, it is determined whether data of the actual voltage AV and the actual current AI of the fuel cell stack 201 is readable (that is, whether the operation of the fuel cell is not in a transient state where the operational data thereof fluctuate too widely to acquire). When it is determined that the data is readable, the process proceeds to step S1402. When it is determined that the data is not readable, the process proceeds to step S1404. At step S1402, the actual voltage AV and the actual current AI of the fuel cell stack 201 are measured. At step S1403, the values

measured at step S1402 are stored into the memory.
[0078]
At step S1404, it is determined whether the number of data stored in the memory exceeds a predetermined number γ, 10, for example. When the number of data exceeds the predetermined number, the process proceeds to step S1405. When the number of data does not exceed the predetermined number, the learning process ends. At step S1405, an I-V characteristic correction factor R is calculated as follows: R(i)=IV2(i)/IV(i), R=Σ R(i)/M, wherein i represents an integer from 1 to M, IV2(i) represents data IV2 at each of M points on the curve of the learned I-V characteristic stored in the memory derived from the collected actual voltages AV and actual currents AI, and IV(i) represents data IV at each of M points on the curve of the nominal I-V characteristic having the same current values as those of M points of IV2. R(i)s are thus calculated for M points in the I-V characteristic. The correction factor R is then calculated as an average of M R(i)s.
[0079]
At step S1406, the correction factor R is multiplied by the data IV0 of the reference I-V characteristic equivalent to the nominal I-V characteristic shown in FIG. 3 and FIG. 4, to thereby revise the data IV of the learned I-V characteristic (i.e., IV=IV0×R), then the routine ends.
[0080]
As explained above, at the time of learning the output characteristic of the fuel cell in the fourth embodiment, the I-V characteristic of the fuel cell can be more easily learned in a shorter time than that of the second embodiment, by correcting the basic I-V characteristic based on a small amount of measured actual currents AI and actual voltages AV.
[0081]
In the second, the third and the fourth embodiments, the I-V characteristic learning unit 103 may learn and correct the I-V characteristic of the fuel cell based on an actual temperature of the fuel cell measured by a temperature sensor or thermometer 217 and a plurality of pieces of I-V characteristic data prepared for various fuel cell temperatures. With this configuration, even when the temperature of the fuel cell changes, the learned I-V characteristic thereof can be more accurate, whereby the control of power generation thereof can be achieved with enhanced precision.
[BRIEF DESCRIPIION OF THE DRAWINGS]
The invention will now be described with reference to the accompanying drawings wherein:

FIG. 1 is a diagram showing a configuration of a power generation control system for a fuel cell according to a first embodiment of the present invention;

FIG. 2 is a diagram showing a configuration of a fuel cell system that includes the power generation control system of FIG. 1;

FIG. 3 is a graph showing an output characteristic (i.e., a characteristic curve showing a relationship between output current and output voltage) of the fuel cell according to the first embodiment;

FIG. 4 is a diagram showing a configuration of a power generation control system for a fuel cell according to a second embodiment of the present invention;

FIG. 5 is a flowchart showing a process of controlling power generation of the fuel cell according to the second embodiment;

FIG. 6 is a flowchart showing a learning process of the I-V characteristic of the fuel cell according to the second embodiment;

FIG. 7 is a flowchart showing a process of calculating target power generation amount P0 [W] according to the second embodiment;

FIG. 8 is a flowchart showing a process of calculating target current I1 according to the second embodiment;

FIG. 9 is a flowchart showing a process of calculating target gas operation point according to the second embodiment;

FIG. 10 is a graph showing the I-V characteristic of the fuel cell according to the second embodiment;

FIG. 11 is a diagram showing a configuration of a power generation control system for a fuel cell according to a third embodiment of the present invention;

FIG. 12 is a flowchart showing a process of calculating target current I1 according to the third embodiment;

FIG. 13 is a flowchart showing a process of calculating target gas operation point according to the third embodiment; and

FIG. 14 is a flowchart showing a learning process of the I-V characteristic of the fuel cell according to the fourth embodiment.
[DESCRIPTION OF THE CODES]
101: TARGET POWER GENERATION AMOUNT CALCULATING UNIT
102: OPERATION CONDITION MONITORING UNIT
103: OUPUT CHARACTERISTIC LEARNING UNIT
104: TARGET CURRENT CALCULATING UNIT
105: TARGET GAS OPERATION POINT CALCULATING MEANS
106: COMMAND OUPUT CALCULATING UNIT
107: GAS CONTROL UNIT

201: FUEL CELL STACK
202: HUMIDIFIER
203: COMPRESSOR
204: VARIABLE THROTTLE REGULATOR
205: THROTTLE VALVE
206: PURGE VALVE
207: DEIONIZED WATER PUMP
208: EJECTOR
209: DRIVE UNIT
210: AIR PRESSURE SENSOR
211: HYDROGEN GAS PRESSURE SENSOR
212: AIR FLOW SENSOR
213: HYDROGEN GAS FLOW SENSOR
214: CONTROLLER
215: VOLTMETER
216: AMMETER

{DOCUMENT TITLE} ABSTRACT

[ABSTRACT]
[PROBLEM] There is provided a problem of certainly ensuring the output power and preventing the deterioration and the damage of the fuel cell even if the output characteristic of the fuel cell is lowered.
[MEANS FOR THE SOLUTION]
A target power generation amount calculating means 101 calculates a target power generation amount of a fuel cell, a target current in accordance with the target power generation amount is calculated based upon a power-current characteristic obtained in accordance with an output characteristic of the fuel cell by target current calculating means 104. A command output value for commanding a power generation amount of the fuel cell is calculated based upon the target current and an actual voltage of the fuel cell detected by operation condition monitoring means 102, by command output calculating means 106.
[SELECTIVE DRWAING] Figure 1

{DOCUMENT TITLE} DRWAINGS

Fig. 1
101: TARGET POWER GENERATION AMOUNT CALCULATING UNIT
TARGET POWER GENERATION AMOUNT P0
102: OPERATION CONDITION MONITORING UNIT
ACTUAL VOLTAGE
104: TARGET CURRENT CALCULATING UNIT
CURRENT
POWER GENERATION AMOUNT
CONVERSUION OF POWR GENERATION – CURRENT

TARGET CURRENT I1
105: TARGET GAS OPERATION POINT CALCULATING MEANS
GAS PRESSURE
CURRENT
TARGET GAS PRESSURE
TARGET GAS FLOW RATE
ACTUAL GAS PRESSURE
ACTUAL GAS FLOW RATE
106: COMMAND OUPUT CALCULATING UNIT
COMMAND OUTPUT VALUE
OUTPUT-TAKING CONTROL
107: GAS CONTROL UNIT

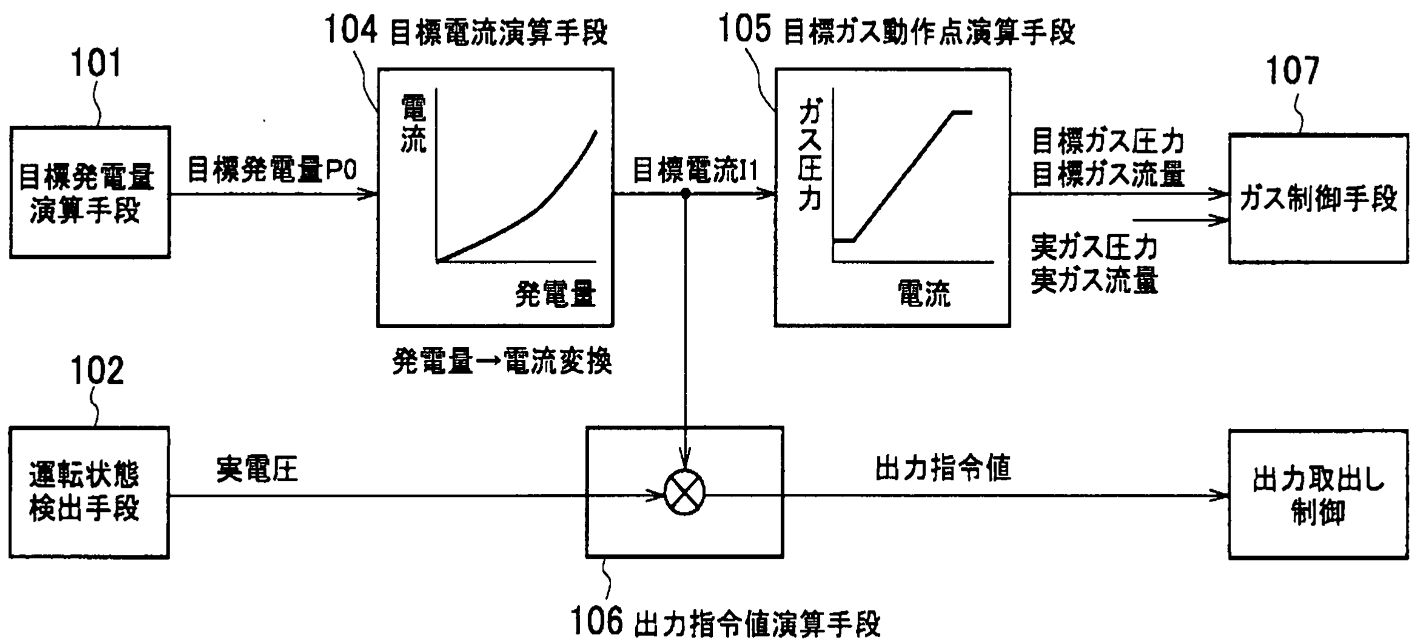
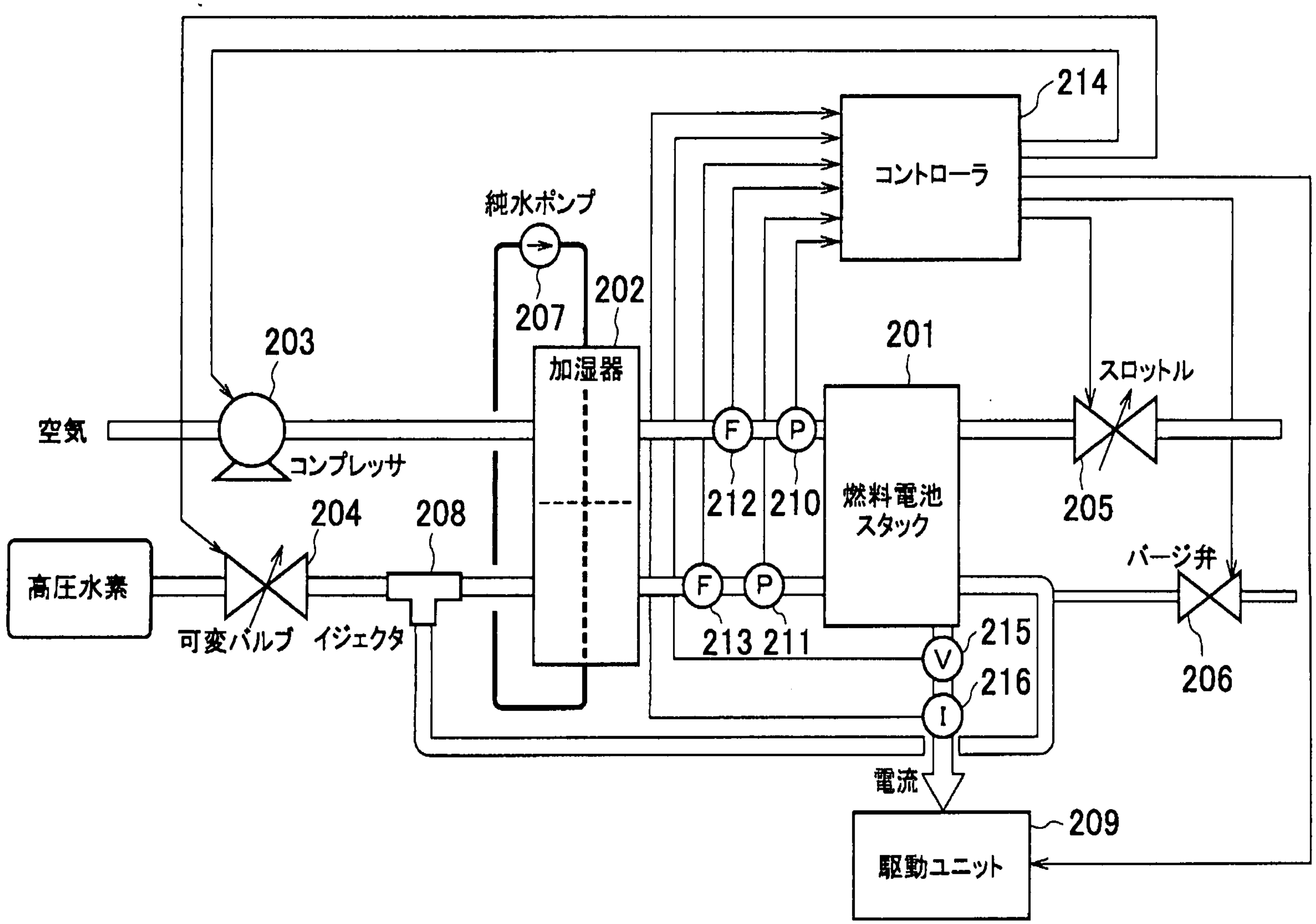

101
目標発電量
演算手段
目標発電量P0
104 目標電流演算手段
電流
発電量
発電量→電流変換
目標電流I1
105 目標ガス動作点演算手段
ガス圧力
電流
目標ガス圧力
目標ガス流量
実ガス圧力
実ガス流量
107
ガス制御手段
102
運転状態
検出手段
実電圧
106 出力指令値演算手段
出力指令値
出力取出し
制御

Fig. 2
201: FUEL CELL STACK
202: HUMIDIFIER
AIR
203: COMPRESSOR
HIGH-PRESSURE HYDROGEN GAS
204: VARIABLE THROTTLE REGULATOR
205: THROTTLE VALVE
206: PURGE VALVE
207: DEIONIZED WATER PUMP
208: EJECTOR
209: DRIVE UNIT
214: CONTROLLER
CURRENT

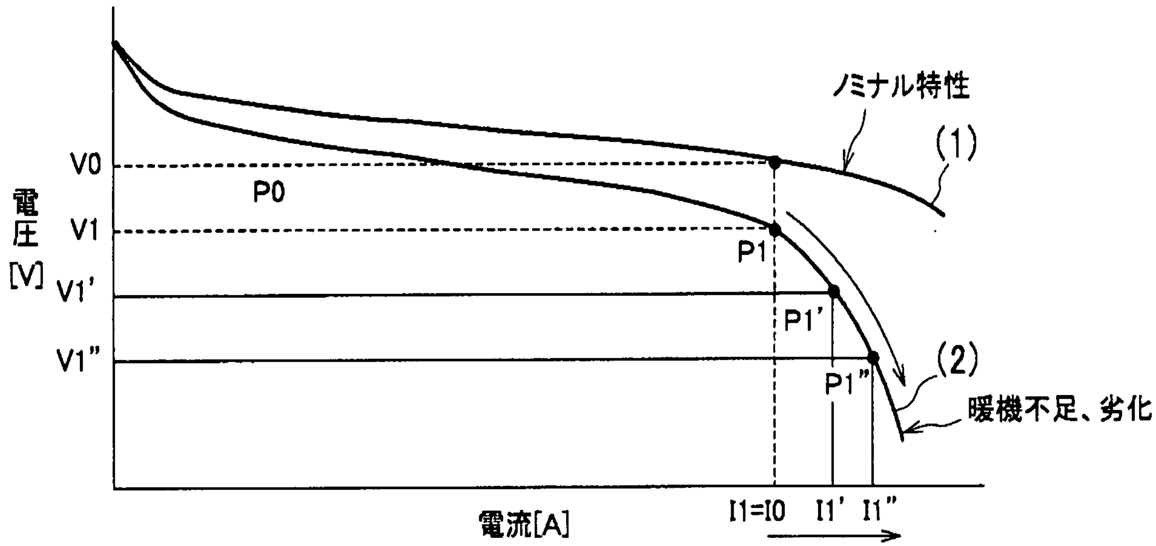
【図２】



214
コントローラ
純水ポンプ
207
202
203
201
加湿器
スロットル
空気
F
P
コンプレッサ
212
210
燃料電池
スタック
205
204
208
バージ弁
高圧水素
F
P
可変バルブ
イジェクタ
213
211
215
V
216
I
206
電流
209
駆動ユニット

Fig. 3
VOLTAGE [V]
CURRENT [A]
(1) NOMINAL CHARACTERISTIC
(2) LACK OF WARMING-UP, DETERIORATION

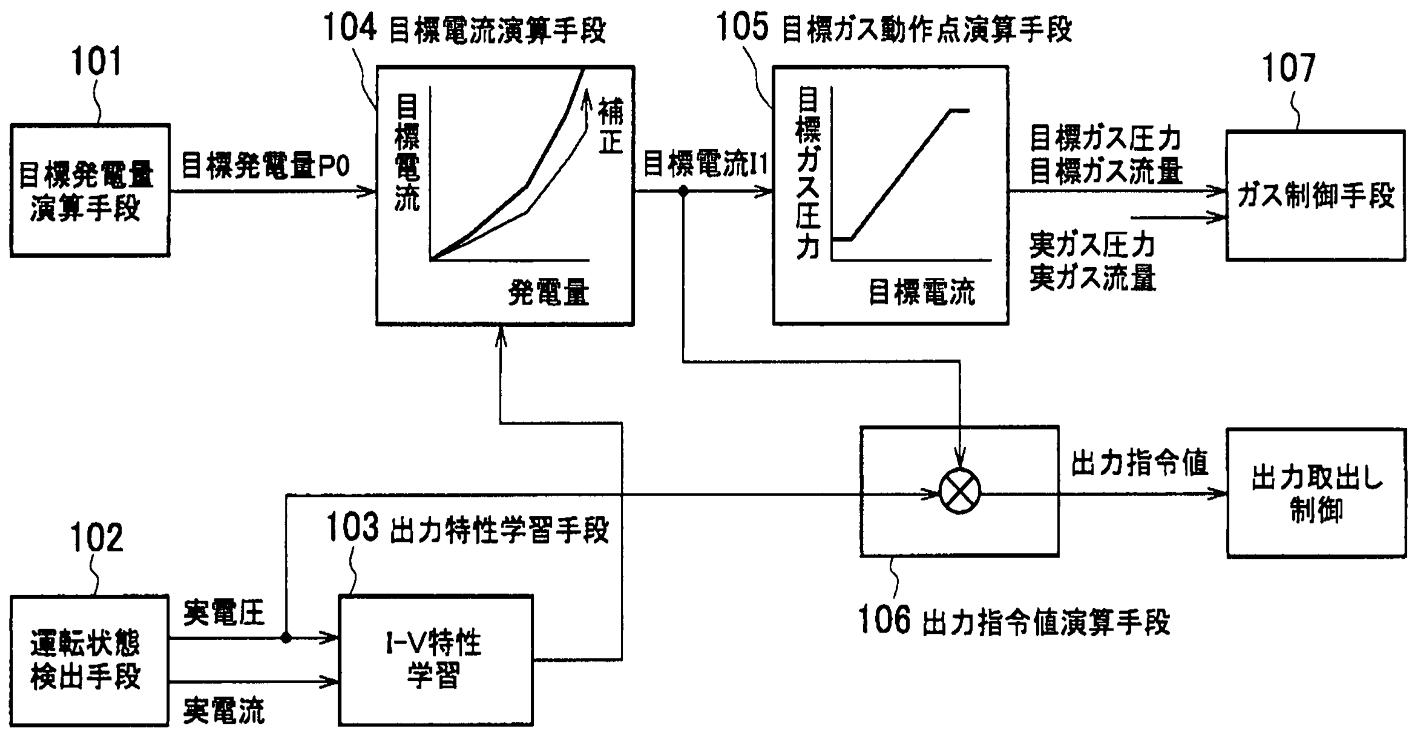
【図３】



ノミナル特性
(1)
V0
P0
電圧
[V]
V1
P1
V1'
P1'
V1"
(2)
P1"
暖機不足、劣化
電流[A]
I1=I0
I1'
I1"

Fig. 4
101: TARGET POWER GENERATION AMOUNT CALCULATING UNIT
TARGET POWER GENERATION AMOUNT P0
102: OPERATION CONDITION MONITORING UNIT
ACTUAL VOLTAGE
ACTUAL CURRENT
103: OUTPUT CHARACTERISTIC LEARNING MEANS
I-V CHARACTERISTIC LEARNING
104: TARGET CURRENT CALCULATING UNIT
TARGET CURRENT
POWER GENERATION AMOUNT
CORRECTION
TARGET CURRENT I1
105: TARGET GAS OPERATION POINT CALCULATING MEANS
TARGET GAS PRESSURE
TARGET CURRENT
TARGET GAS PRESSURE
TARGET GAS FLOW RATE
ACTUAL GAS PRESSURE
ACTUAL GAS FLOW RATE
106: COMMAND OUPUT CALCULATING UNIT
COMMAND OUTPUT VALUE
OUTPUT-TAKING CONTROL
107: GAS CONTROL UNIT

【図４】



101
目標発電量
演算手段
目標発電量P0
104 目標電流演算手段
目標電流
発電量
補正
目標電流I1
105 目標ガス動作点演算手段
目標ガス圧力
目標電流
目標ガス圧力
目標ガス流量
実ガス圧力
実ガス流量
107
ガス制御手段
102
運転状態
検出手段
実電圧
実電流
103 出力特性学習手段
I-V特性
学習
出力指令値
106 出力指令値演算手段
出力取出し
制御

Fig. 5
S501: CALCULATE A TARGET POWER GENERATION AMOUNT (P0)
S502: CALCULATE A TARGET CURRENT (P1)
S503: CALCULATE A TARGET GAS OPERATION POINT
S504: PERFORM CONTROL OF GAS PRESSURE AND GAS FLOW RATE
S505: DETECT AN ACTUAL VOLTAGE (VFC)
S506: CALCULATE A COMMAND OUTPUT VALUE
S507: PERFORM OUTPUT CONTROL

【図５】

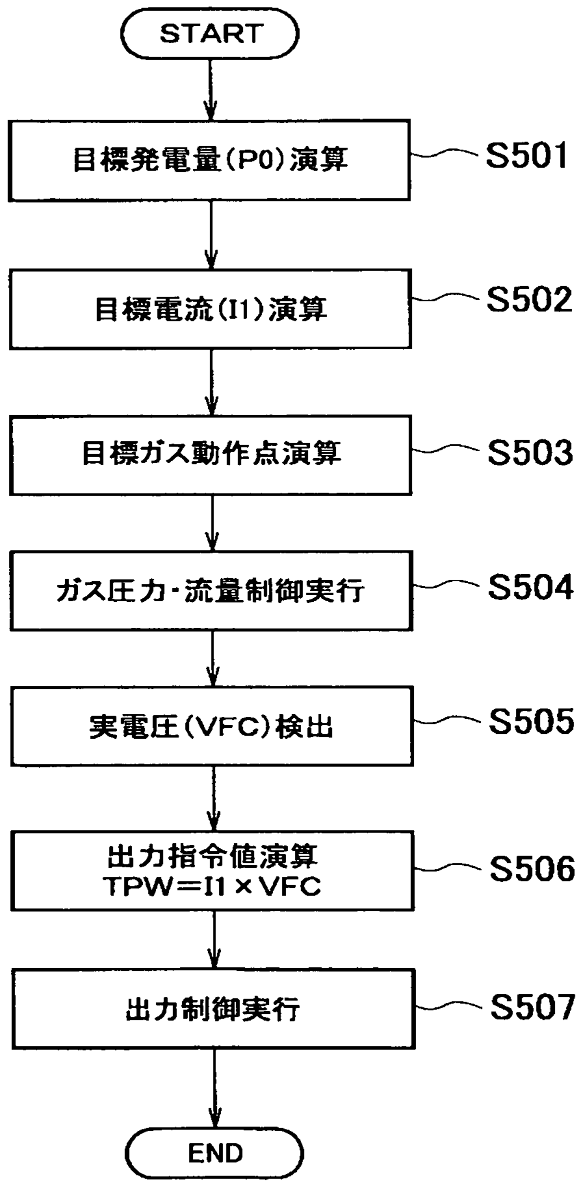

START
目標発電量(P0)演算
S501
目標電流(I1)演算
S502
目標ガス動作点演算
S503
ガス圧力・流量制御実行
S504
実電圧(VFC)検出
S505
出力指令値演算
TPW=I1×VFC
S506
出力制御実行
S507
END

FIG. 6

S601: IS IT POSSIBLE TO OBTAIN DATA ?

S602: DETECT AN ACTUAL VOLTAGE (VFC) AND AN ACTUAL CURRENT (IFC)

S603: STORE A DETECTION VALUE IN A MEMORY

S604: DATA NUMBER $> \alpha$?

S605: LEARNING TIME $> \beta$?

S606: UPDATE I-V CHARACTERISTIC (IV-IV1)

【図６】

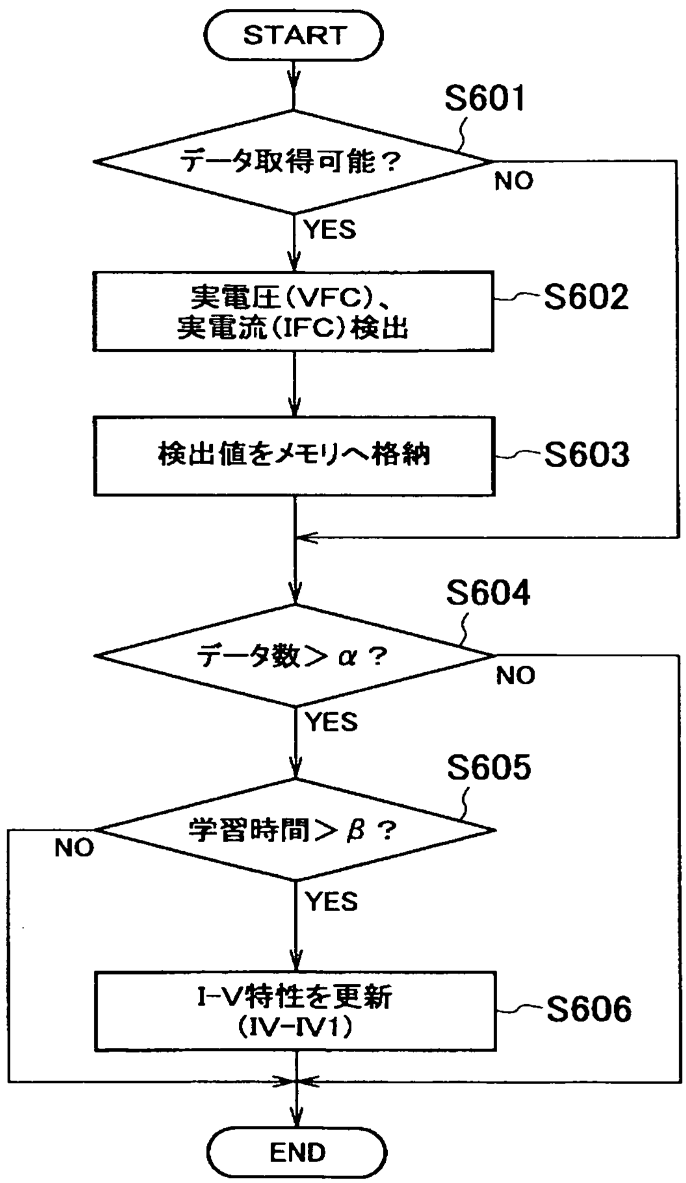

START
S601
データ取得可能？
NO
YES
実電圧(VFC)、
実電流(IFC)検出
S602
検出値をメモリへ格納
S603
S604
データ数＞α？
NO
YES
S605
学習時間＞β？
NO
YES
I-V特性を更新
(IV-IV1)
S606
END

FIG. 7
CALCULATE A TARGET POWER GENERATION AMOUNT (P0)
S701: UPDATE POWER DATA OF AN AUXILIARY DEVICE ?
S702: READ IN LATEST I-V CHARACTERISTIC
S703: CALCULATE Pgross-I CHARACTERISTIC
S704: CALCULATE Pgross-Paux CHARACTERISTIC
S705: CALCULATE Pnet-Paux CHARACTERISTIC
S706: READ IN A TARGET Net POWER GENERATION AMOUNT
S707: CALCULATE COUNSUMPTION POWER OF AN AUXILIARY DEVICE
S708: CALCULATE A TARGET Gross POWER GENERATION AMOUNT

【図７】

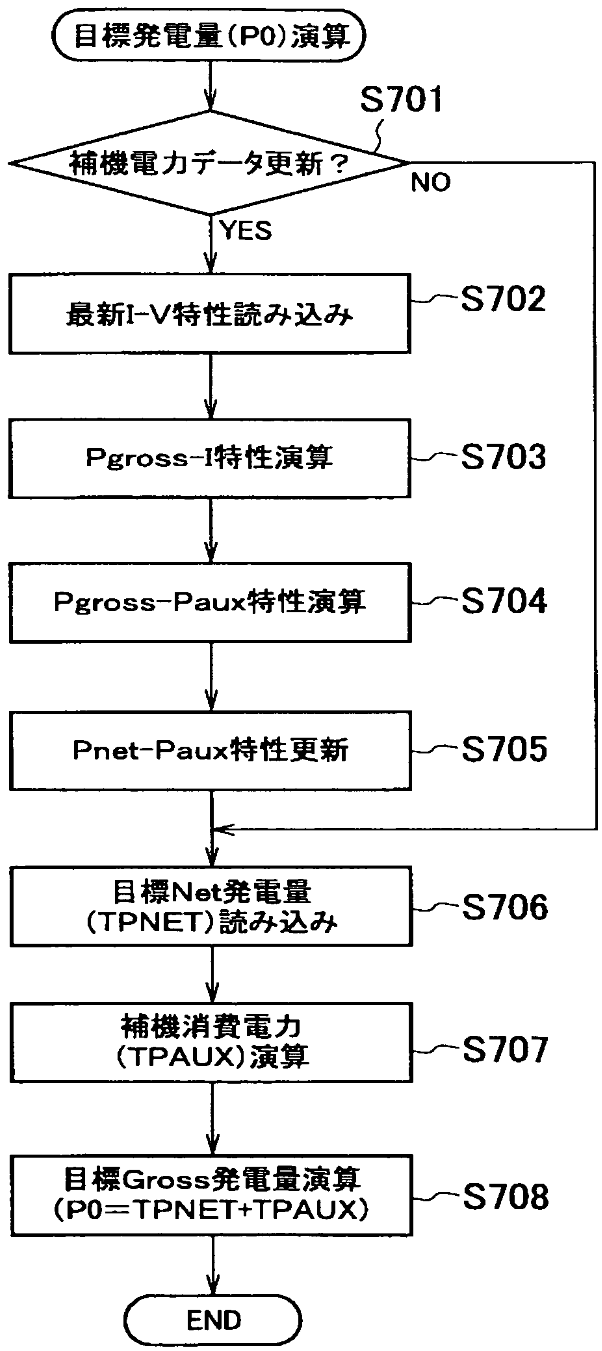

目標発電量(P0)演算
S701
補機電力データ更新？
NO
YES
最新I-V特性読み込み
S702
Pgross-I特性演算
S703
Pgross-Paux特性演算
S704
Pnet-Paux特性更新
S705
目標Net発電量
(TPNET)読み込み
S706
補機消費電力
(TPAUX)演算
S707
目標Gross発電量演算
(P0=TPNET+TPAUX)
S708
END

FIG. 8
CALCULATE A TARGET CURRENT (I1)
S801: READ IN LATEST I-V CHARACTERISTIC
S802: CALCULATE Pgross-I CHARACTERISTIC
S803: READ IN A TARGET Gross POWER GENERATION AMOUNT (P0)
S804: CALCULATE A TARGET CURRENT (I1)

【図８】

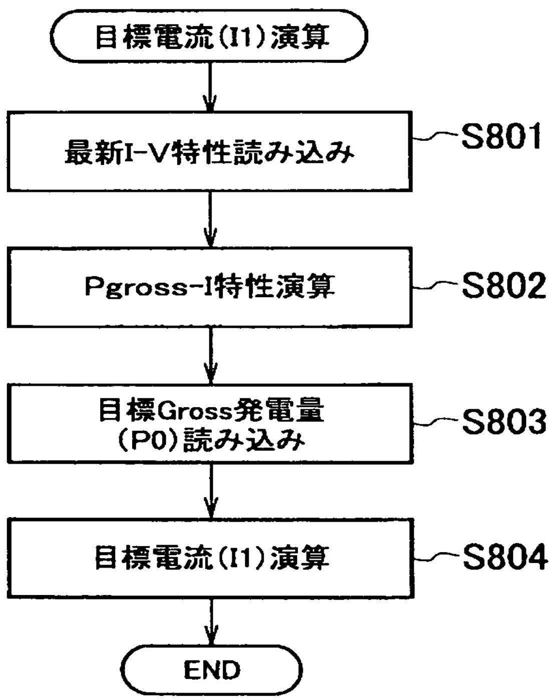
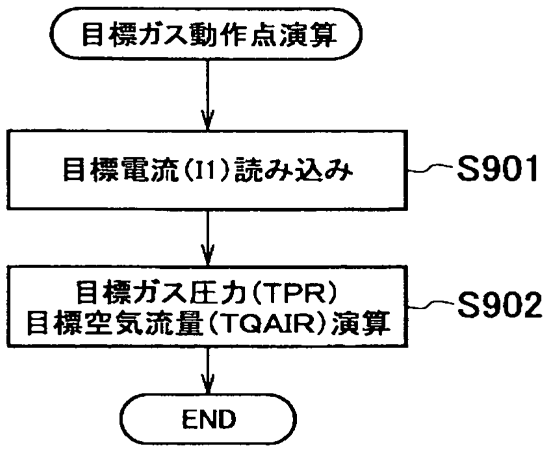


FIG. 9
CALCULATE A TARGET GAS OPERATION POINT
S901: READ IN A TARGET CURRENT (I1)
S902: CALCULATE A TARGET GAS PRESSURE (TPR) ANS A TARGET AI R FLOW RATE (TQAIR)

【図９】



目標ガス動作点演算
目標電流(I1)読み込み
S901
目標ガス圧力(TPR)
目標空気流量(TQAIR)演算
S902
END

Fig. 10
VOLTAGE [V]
CURRENT [A]
(1) NOMINAL CHARACTERISTIC
(2) OPERATION POINT CONTROL

【図１０】

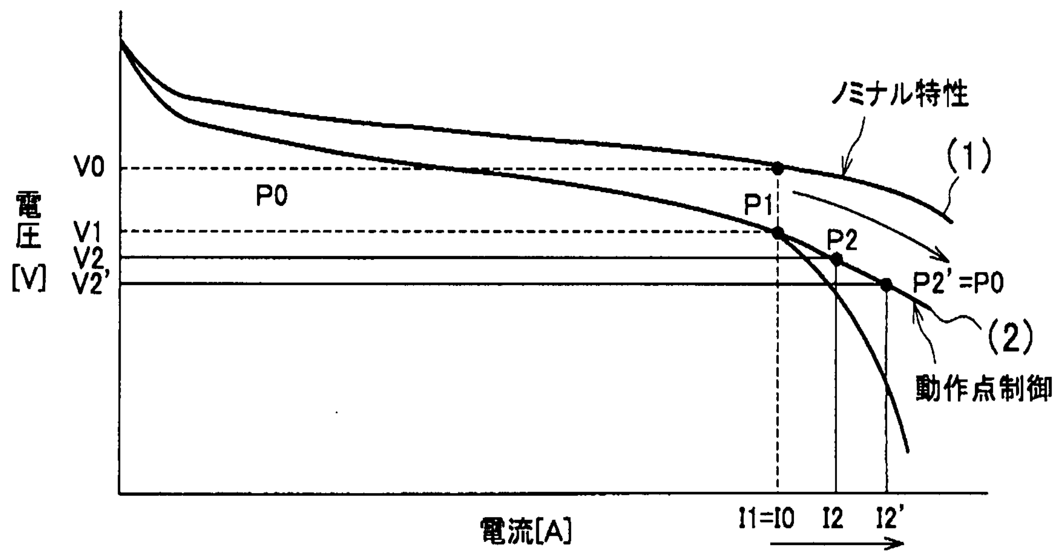

電圧
[V]
V0
V1
V2
V2'
P0
P1
P2
P2'=P0
ノミナル特性
(1)
(2)
動作点制御
電流[A]
I1=I0
I2
I2'

Fig. 11
101: TARGET POWER GENERATION AMOUNT CALCULATING UNIT
TARGET POWER GENERATION AMOUNT P0
102: OPERATION CONDITION MONITORING UNIT
ACTUAL VOLTAGE
ACTUAL CURRENT
103: OUTPUT CHARACTERISTIC LEARNING MEANS
I-V CHARACTERISTIC LEARNING
104: TARGET CURRENT CALCULATING UNIT
TARGET CURRENT
POWER GENERATION AMOUNT
CORRECTION
TARGET CURRENT I1
105: TARGET GAS OPERATION POINT CALCULATING MEANS
TARGET GAS PRESSURE
TARGET CURRENT
TARGET GAS PRESSURE
TARGET GAS FLOW RATE
ACTUAL GAS PRESSURE
ACTUAL GAS FLOW RATE
106: COMMAND OUPUT CALCULATING UNIT
COMMAND OUTPUT VALUE
OUTPUT-TAKING CONTROL
107: GAS CONTROL UNIT

【図１１】

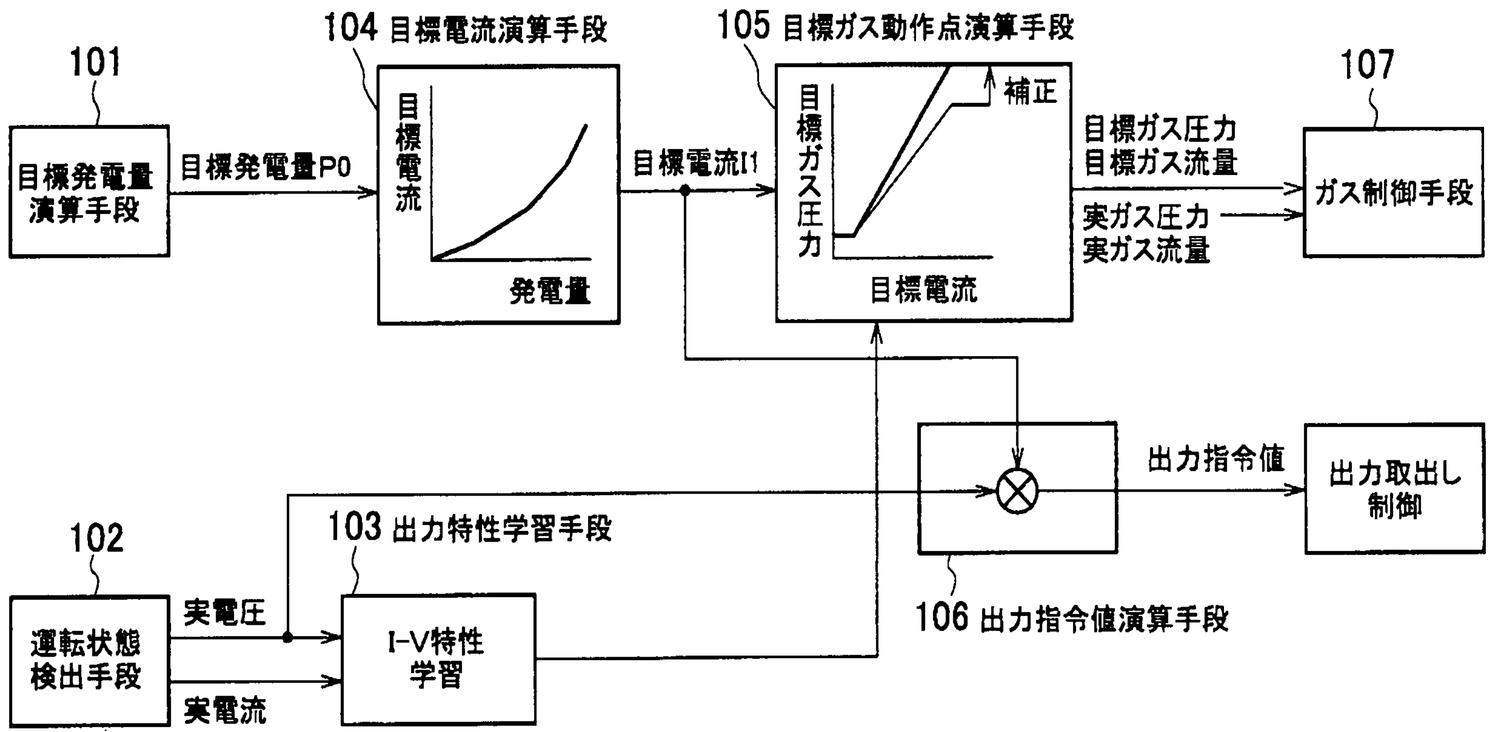

101
目標発電量演算手段
目標発電量P0
104 目標電流演算手段
目標電流
発電量
目標電流I1
105 目標ガス動作点演算手段
目標ガス圧力
目標電流
補正
目標ガス圧力
目標ガス流量
実ガス圧力
実ガス流量
107
ガス制御手段
102
運転状態検出手段
実電圧
実電流
103 出力特性学習手段
I-V特性学習
106 出力指令値演算手段
出力指令値
出力取出し制御

FIG. 12
CALCULATE A TARGET CURRENT (I1)
S1201: READ IN A TARGET Gross POWER GENERATION AMOUNT (P0)
S1202: CALCULATE A TARGET CURRENT (I1)

【図１２】

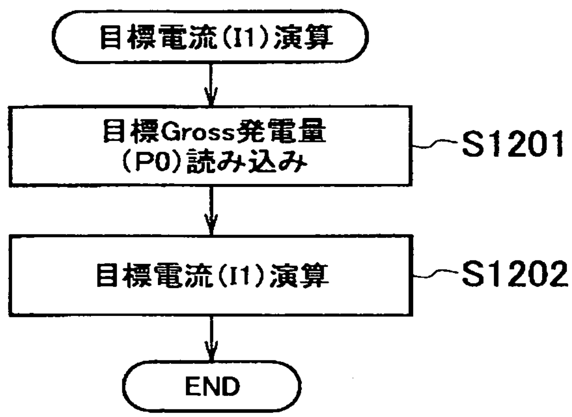
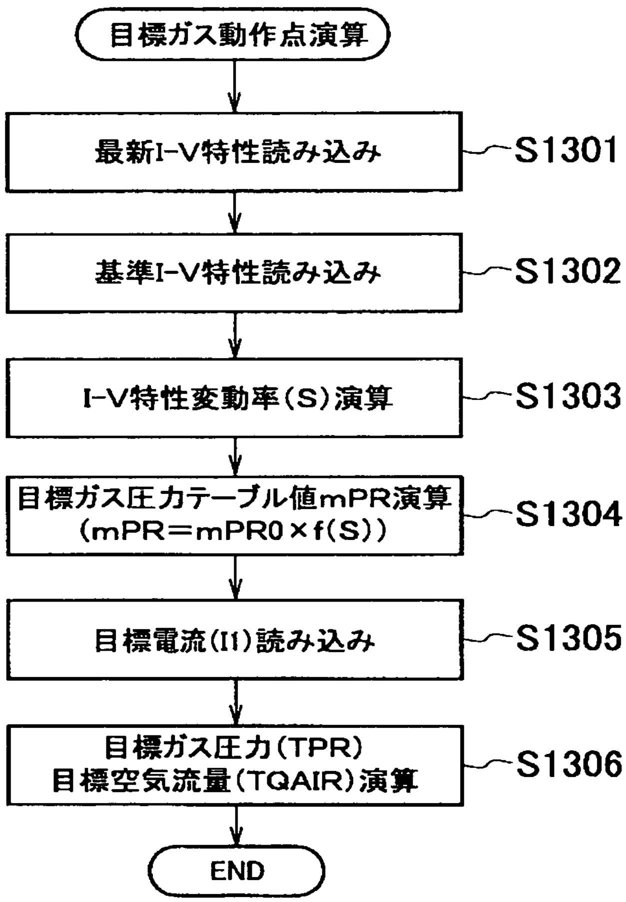


FIG. 13
CALCULATE A TARGET GAS OPERATION POINT
S1301: READ IN A LATEST I-V CHARACTERISTIC
S1302: READ IN A REFERENCE I-V CHARACTERISTIC
S1303: CALCULATE I-V CHARACTERISTIC VARIATION RATE (S)
S1304: CALCULATE A TABLE VALUE mPR OF A TARGET GAS PRESSUR
E
S1305: READ IN A TARGET CURRENT (I1)
S1306: CALCULATE A TARGET GAS PRESSURE (TPR) ANS A TARGET AI
R FLOW RATE (TQAIR)

【図１３】



目標ガス動作点演算
最新I-V特性読み込み
S1301
基準I-V特性読み込み
S1302
I-V特性変動率（S）演算
S1303
目標ガス圧力テーブル値mPR演算
（mPR＝mPR0×f(S)）
S1304
目標電流（I1）読み込み
S1305
目標ガス圧力（TPR）
目標空気流量（TQAIR）演算
S1306
END

FIG. 14

S1401: IS IT POSSIBLE TO OBTAIN DATA ?

S1402: DETECT AN ACTUAL VOLTAGE (VFC) AND AN ACTUAL CURRENT (IFC)

S1403: STORE A DETECTION VALUE IN A MEMORY

S1404: DATA NUMBER $> \gamma$?

S1405: CALCULATE AN I-V CHARACTERISTIC CORRECTION RATE (R)

S1406: UPDATE I-V CHARACTERISTIC (IV-IV0 $\times$ R)

【図１４】